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Pre-service teachers using the Knowledge Quartet as a tool to analyse and reflect on their own teaching

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This paper reports a qualitative study of the post-lesson reflections of two pre-service teachers in Norway. During their third school placement, Nora and Mia volunteered to use the Knowledge Quartet to analyse and reflect on their own mathematics teaching. Comparing the nature of their reflections at the start and at the end of the placement, we find that Nora and Mia exhibit some development, focusing more on mathematical content at the end of the study than in the beginning. Factors that can influence their reflections are discussed: their own experience of mathematics and their beliefs about mathematics seemed to play an important role in how they interpreted and made use of the framework.

Keywords: Mathematics teacher education, teacher background, elementary school mathematics, teacher practicum placement, Knowledge Quartet.

Introduction

The apparent disconnect between teacher education and the practice of teaching is of great concern to teacher educators (e.g., Solomon, Eriksen, Smestad, Rodal, & Bjerke, 2015). Systematic reflection on teaching might reduce this fragmentation, providing an educational experience based on genuine classroom experiences. However, teacher educators face the challenge of encouraging pre-service teachers to engage with classroom data in a meaningful way. In mathematics, in particular, research efforts have been made to find ways of focusing attention on mathematics as opposed to general pedagogy, with the ultimate goal of helping mathematics teachers (both pre- and in-service) to develop their teaching. The Knowledge Quartet (KQ) is an example of a research-based theory that resulted from this research effort (Rowland, Huckstep, & Thwaites, 2005). Through two case studies (Flesvig, 2016), this paper explains and exemplifies the situated challenge of using the KQ to reflect on mathematics teaching.

The research questions are: “To what extent does using the KQ as an analytical tool influence what pre-service teachers' (PSTs') attend to in the analysis of their own mathematics teaching? How do PSTs describe their experiences of using the KQ for lesson analysis?”

Literature review

Teacher education programmes prioritize increasingly the ‘core practices’ of teaching. The debate as to what these might be and what it means to focus on these in teacher education is ongoing (McDonald, Kazemi, & Kavanagh, 2013). We support the view that analyzing teaching is one such core practice:

[it] involves learning to decompose instructional practice, to attend to particular events and interactions that are considered consequential for student learning, and to interpret the meaning behind those events to make informed teaching decisions. (Sun & van Es, 2015, p. 201)

The underlying assumptions are that engaging in analysis of teaching, and focusing on the details of the mathematical aspects involved and on students' mathematical thinking, will result in development of mathematical knowledge for teaching, as well as in more responsive teaching. There is evidence that the first assumption holds true both for PSTs (Turner, 2012) and for in-service teachers (Llinares & Krainer, 2006). While the second assumption is yet not well documented, Sun & van Es (2015) confirm it in their study of secondary PSTs exposed to a course with a focus on analysis of video recordings of the participants' own mathematics teaching.

Providing PSTs with opportunities to analyse teaching is not enough. PSTs need tools to direct their attention to salient aspects of teaching episodes. While focusing their reflections on the taught content (mathematics) is not a given either for in-service teachers or for PSTs, research provides examples to show that this is a trainable skill (Turner, 2012; Star & Strickland, 2008; Sun & van Es, 2015). Examples of 'tools' that support the process include frameworks for analysis of teaching (Rowland et al., 2005, Star & Strickland, 2008), routines for discussion of videos (Sun & van Es, 2015), and experienced mentor support to direct post-lesson review to focus on mathematics (Nilssen, 2010).

In theory, school 'practicum' placements should provide PSTs with excellent opportunities to reflect on the details of teaching, under the supervision of experienced teacher mentors. However, research has shown that there are significant differences in the experience of school placement of individual PSTs and that school placement is mostly about managing and doing the teaching, less about learning systematically from it (Solomon et al., 2015). This makes it all the more interesting for teacher educators to explore ways of supporting, with minimal involvement, PSTs' structured reflections on mathematics teaching in their school placements.

Theoretical underpinnings of the study

The nature of reflections on mathematics lessons

While we argued for the value (and difficulty) of attending to mathematics content in PSTs' lesson analysis, we recognise other salient aspects are likely to feature. To capture these aspects in PSTs' reflections, we turn to the five-category framework of Star & Strickland (2008): classroom environment (class size and level, room layout, equipment, etc.), classroom management (classroom events and procedures), tasks (worksheets, presentations, homework, etc.), mathematical content (the topic, representations, examples, problems) and communication (questions asked, suggestion offered). The framework has been used as an instructional tool in two separate studies based on analysing video, leading to improved skills in observing classroom environment and communications (Star & Strickland, 2008; Star, Lynch & Perova, 2011). However, attention to the categories 'tasks' and 'mathematical content' seems harder to promote, and did not improve in the second study. For this reason, we chose another instructional tool for our study.

The Knowledge Quartet

The Knowledge Quartet (KQ) is a framework that classified the situations in which mathematics teachers' knowledge comes into play, in four broad categories: foundation, transformation, connection and contingency. The framework is empirically grounded in classroom observations, and the four categories encompass in total 20 different codes (Rowland, 2014). For example, foundation includes codes such as overt display of subject knowledge, adherence to textbook, concentration on procedures. Transformation encompasses ways of making the mathematics accessible to learners, such as choice of examples and choice of representation. Connection includes, for instance, both connections between concepts and sequencing within a lesson. Contingency is the dimension capturing unexpected events in the lesson, for instance in responding to students' ideas.

The KQ is used to analyse mathematics teaching with a focus on teacher knowledge, and is an appropriate tool to analyse and develop mathematics teaching when used in cooperation by PSTs, teacher mentors and teacher educators (Rowland, Huckstep & Thwaites, 2005). It has been successfully used as “an analytical framework to identifying mathematical content knowledge revealed through observations of practice” in a study with in-service teachers (Turner, 2012, p. 256). The participants, who collaborated closely with the researcher and were given considerable support in using the framework, saw the KQ as a tool to support them in reflecting more critically on their own teaching (Turner, 2012). This focus on the mathematics stands in contrast with the general pedagogical and organisational features of the lesson typically addressed in post-lesson review sessions between teacher mentors and PSTs (Solomon et al., 2015). The KQ is a means “to support focused reflection on the mathematical content of teaching” (Turner, 2012, p.253).

Methodology and methods

This paper reports on case studies of two PSTs' reflections on their mathematics teaching in school *practicum* placement. At the time of the study, the participants, called here Mia and Nora, were in their second year of a four-year Norwegian teacher education programme for grades 5-10 (age 10-15), specialising in mathematics. They were in the third school placement of their programme, and were based in the same grade 5 class.

Prior to the school placement, Mia and Nora attended a training session with the first author. This included a presentation of the KQ, and a joint analysis of a video from a Norwegian classroom. Nora and Mia were invited to use the KQ to analyse each mathematics lesson in their school placement. Since Mia and Nora were aware of the design of the study when they volunteered to participate, we expect that they attempted to use the framework as faithfully as possible.

Data collection included observations of two mathematics lessons for each participant, the first and the last of those taught in that third school placement (two weeks apart), followed immediately by audio-recorded semi-structured interviews. In the observed lesson, Mia and Nora taught statistics, and in the second they taught decimal numbers. This paper considers data from the interviews, since it is the PST's *reflections* on teaching, rather than the teaching itself, that will be analysed. However, the lessons were videotaped for stimulated recall during the interviews, and to allow recall of episodes discussed in the interviews.

The interview guides for the two interviews had a common core, and some additional questions that differed (regarding participants' background in the first interview, and regarding their experiences of using the KQ in the last interview). The core was structured around the dimensions of the KQ ("Last time we talked you mentioned being concerned with how tasks are sequenced. What about this lesson?"), but also included more open questions about the lesson observed ("Tell me about an episode you remember from this lesson. Why did this episode catch your attention?"). The interviews were transcribed and analysed in the original language (Norwegian), by the first author. The excerpts included in this paper were translated into English by the authors.

Given the design of the interview guide, with some open questions and some directly connecting to the KQ, this framework is not sufficient as the analytical tool. In this paper, our analysis draws on the framework of Star & Strickland (2008). This framework gives insight into the nature of the participants' reflections on their mathematics teaching, and their development during the school placement during which the study took place.

Participants

At the time of the study Mia and Nora were in their third school placement (lasting 13 days), both based in the same class (grade 5, age 10) under the supervision of the same teacher mentor. Both Mia and Nora had some experience working as (unqualified) substitute teachers.

While confident in her mathematics knowledge, Mia wanted more in terms of mathematics pedagogy and this was her motivation for participating in this study. She had enrolled in her current grades 5-10 teacher education programme after dropping out from a programme for mathematics teachers for grades 8-13 (age 13-18) in disappointment with the courses: "It was all about computations... there was nothing about putting it [the maths] across".

Nora found mathematics "fun, at least in grades 1-7", but to gain admission to the teacher education programme, she had to retake the final mathematics exam (grade 12). In teacher education, Nora experienced a "steep transition from upper secondary, quite a few notches over that". In the first interview she described mathematics as her favourite subject to teach, but was dissatisfied with the course: "A lot of what we learn is not what we will teach, and there is no use for it in our professional lives, while at the same time I miss something on how to teach the very basic stuff".

Findings

We consider Mia and Nora's reflections on their teaching of the two lessons, and their thoughts on The Knowledge Quartet. Some data from the videos is included by way of context for the interviews.

Interview 1 - Mia's reflection on her teaching

In the post-lesson interview following Mia's first lesson, some questions were directed towards specific dimensions of The Knowledge Quartet, such as transformation. Mia was asked how she selected tasks for her class. She mentioned that she does look at the textbook first, but she supplements the materials with additional problems that she finds online and selects carefully:

I make sure they target the age group, fifth grade. That one [task on the handout] was actually a challenge for fourth grade, I found it online [...]. But it was about inserting, rather than drawing

the chart, and there are no such tasks in the textbook. I always look for tasks that fit the topic and the age group and that complement the textbook, otherwise there is no point in it.

Interview 2 - Mia's reflection on her teaching and on using The Knowledge Quartet

The last lesson, like the first, had a traditional structure, with Mia showing some examples, then the students worked individually until the lesson ended, without any summary or discussion. Mia was invited to mention something she noticed during the lesson:

I remember best and I was most surprised by how well the students remember from [...] the first lesson about decimal numbers. In that lesson I felt they got something out of it, but not everything, because it was hard. But now I suddenly felt that there were very many who were eager and who knew something about it [decimal numbers].

The interview included questions on the dimensions of The Knowledge Quartet, related to specific situations from the lesson observed. In terms of transformation, Mia commented on the role of the textbook and the choice of tasks and examples:

I only use it [the textbook] to see what it says, given that the students will solve problems from there, so my teaching shouldn't deviate too much from it. But I don't really use it when I teach as such, then I use examples and tasks I prepared myself, that are suitable for the children. And these are [...] examples I choose carefully so that I know them well if I get questions.

At the end of the interview, Mia was asked about her thoughts on the KQ:

I had one lesson that I was really unhappy with, while my mentor thought it hadn't been so bad. But I was really irritated [...] so I used it [the KQ], because I was really angry. I went carefully through all the codes and categories. I'm thinking this should be done when the lesson goes well, too, because it really helped me when it went poorly [...] I discovered that - here is something positive, and here as well. It wasn't all negative, although it felt that way to begin with.

Interview 1 - Nora's reflection on her teaching

Nora's first lesson was in statistics. The lesson had a traditional structure, starting with recalling and writing down definitions, solving a few problems on the interactive board, and then individual work.

Asked about the transformation dimension, about her choice of tasks and their sequencing, Nora explained:

I asked first for the definition of the mode and the median, since they'd learned that earlier. [I asked them] to check if they remembered what they'd been told earlier. [...] They have a rulebook where it's good to write down things like this, so we started there, because I thought at least they have it there.

The interviewer asked her to explain her choice of tasks, why she considered them good, and why they were selected for the session on the interactive board:

Because there was a bit of variation. But after a while ... Well, there were [in the online resource of the textbook] ten levels [of difficulty]. That's a bit much, so I stopped a bit earlier. [...] It would have been too much of the same, but six-seven is okay, a chance to drill.

Interview 2 - Nora's reflection on her teaching and on using the Knowledge Quartet

Nora continued the lesson on decimal numbers from where Mia left off, continuing with individual work and then the whole class worked on exercises on the interactive board.

In the interview, she was invited to mention something she remembered from the lesson:

The students worked individually for a long time, so I had to find some additional tasks [from the textbook] since they solved them much faster than I thought. So I just let them know [...] that they can carry on to the next page.

Invited to use the KQ to analyse the lesson itself, Nora recalls a contingent moment:

One girl asked [...] if the distance between 0.7 and 1.1 on the number line is 4. Then I answered that she has to think of the whole number line: here's 0 and here's 1, there is a whole between them. Do you think there are four between [0.7 and 1.1]? No, so then it's 0.4.

In this final interview, Nora was asked about her experience using KQ so far and if she thinks she might continue using it. She admitted that it can be helpful in reassessing a situation ("might not think of it without all these points") that might otherwise be overlooked ("so much happens during a lesson") and this will help to revise the teacher's approach next time. However, the traditional post-lesson review session appeals to her:

I think it's helpful to talk about what happened in the lesson anyway, and we [Nora, Mia and the mentor] talked a lot. Then you get some insight in what is good and what could have been different, and so on.

In her experience, the KQ has "an awful lot of codes and dimensions" and using it resulted in:

... talking more about the lessons. And more about the examples. And sequencing, maybe. But not much otherwise.

Discussion

Mia

With reference to Star, Lynch & Perova's (2011) framework, the categories *tasks* and *classroom management* are especially prominent in Mia's first analysis/interview, both in response to the open questions, and when directed to use the KQ. A turn towards *mathematical content* occurs with more targeted questions about specific dimensions of the KQ, as in the case of transformation. By contrast, in her second analysis/interview Mia observed and reflected with *mathematical content* in mind, barely touching upon *classroom management*. Answering open questions, she refers to *tasks* and *communication*, without using any of the terms from the KQ. However, this changes when she goes deeper into her lesson using the KQ framework, with Mia using the terminology of the KQ, with attention to *mathematical content*, as well as *tasks* and *classroom management* in general. Questions on the dimensions of the KQ, such as the transformation dimension, direct Mia's focus to the fine grain of *mathematical content*.

Mia is convinced that the KQ supports a focus on the details of mathematics lesson. She pinpoints a specific situation in which breaking down the events of a lesson with the KQ helped her see

strengths, not only weaknesses in her teaching, thus regaining her confidence as a mathematics teacher, at a time when her mentor's more general feedback was not helping her.

Nora

Throughout her first teaching analysis/interview, Nora's reflections focused most on *tasks*, *classroom management* and to some extent *communication*, only superficially touching on the *mathematical content*. Even when the questions directed her to the KQ, she never actively used the terminology of the framework. In the second analysis/interview, Nora focused mostly on *mathematical content*. Although initially focusing on *tasks*, there was a clear change in emphasis towards *mathematical content* when she is asked to use the KQ framework, and even more so when the questions are specific to the KQ dimensions.

There is a tension in Nora's statements about using the KQ for teaching analysis. While she recognizes that the KQ creates an opportunity for development by making visible the specifics of a mathematics lesson, Nora prefers the unstructured form of traditional review sessions, explaining this in terms of the burden of the number of codes.

Concluding comment

Comparing the first and the last interview, we see that both Mia and Nora's reflections exhibited an increasing focus on mathematics. A number of factors could play a part in this, including the use of the KQ for analysis of the lessons, the experience of the school placement, and the mentor's guidance in the post-lesson reviews. The data indicate that the KQ does mediate this change, since even in the last interview we see that the more the questions are anchored in the KQ, the more marked the focus on mathematics was.

Both Mia and Nora described the KQ as a means to explore the details of a mathematics lesson, and an opportunity to improve their teaching. However, we see differences in the degree to which they embrace the use of the KQ, with Nora leaving the door open to use it for troubleshooting, and Mia positive to continuing using it both when lessons go well and when they do not. We recognize that there are differences in the mathematical knowledge and mathematics teaching confidence of the two PSTs, and this might play a part in these differences. For instance, analysing in such detail a lesson that 'went well' (as is often said in unfocused post-lesson reviews) is likely to reveal details that were problematic, an insight causing some emotional discomfort. In that case, Nora might have benefitted from receiving more support when using the KQ, to help her cope. Or, perhaps Nora interprets the KQ as an algorithm that requires her to go through the all 20 codes for every lesson, and finds the time commitment too much, in which case she would benefit from more in-depth training in using the KQ in a more holistic and efficient way, perhaps limiting the framework to low-inference codes (e.g. 'choice of examples') to begin with.

In conclusion, the study indicates that, even with minimal support, the KQ can contribute in some cases to focus pre-service teachers' post-lesson reflections on mathematics. Individual differences between the voluntary participants' willingness to continue using KQ after the end of the study suggest that teacher educators need to be mindful of factors that could deter PSTs from using the framework.

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